End-cell Tuning and External Q

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Inner cell design;

now the issues and methods for this design are proved pretty well; such as Ep, Bp, K, k, ….

Multi cell cavity design;

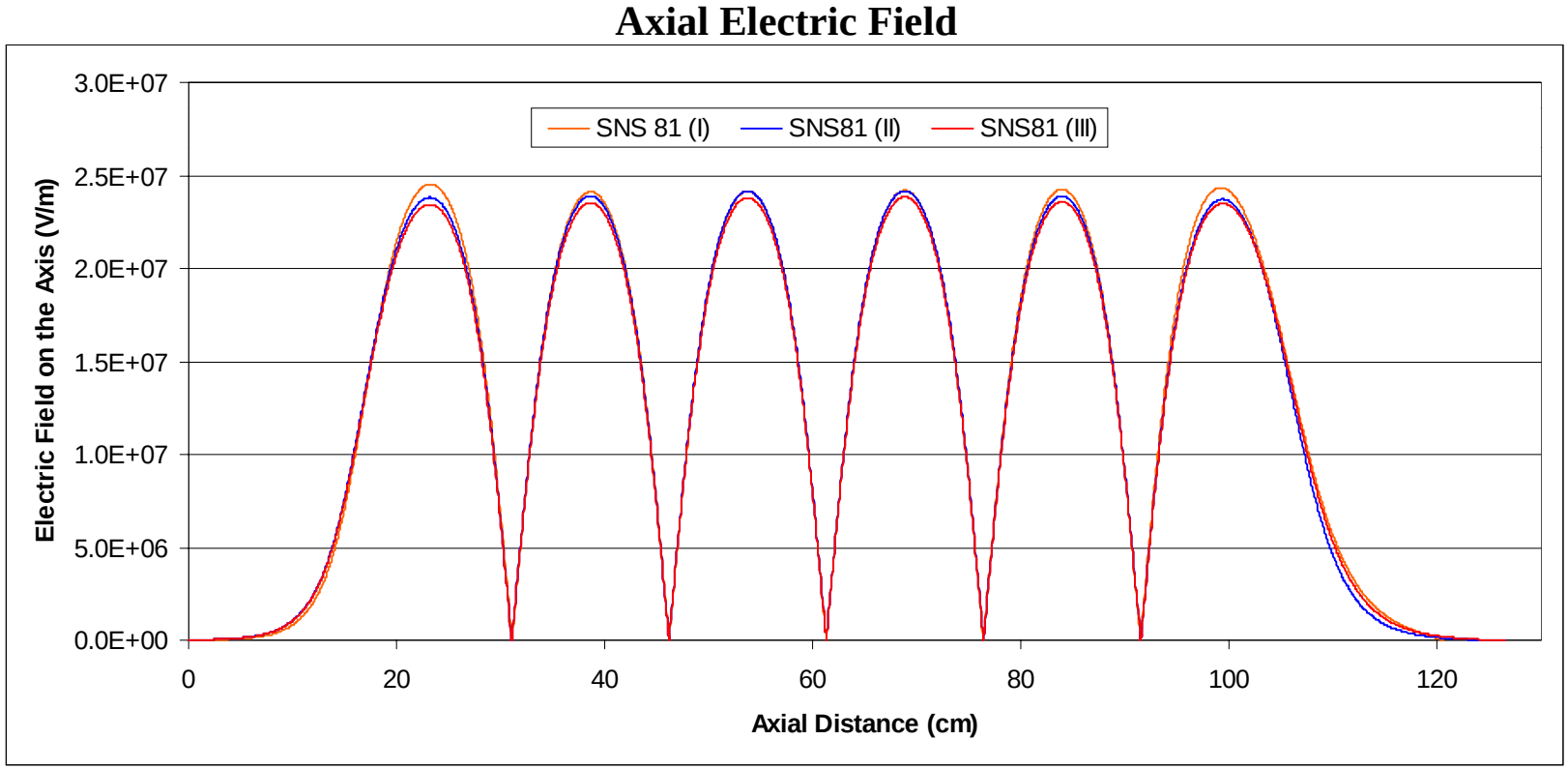
End-cells tuning in order to achieve good field flatness, lower peak surface fields at end cells, and required Qex (and R/Q; variations are small, and HOMs; under progress)

-There can be different geometries those satisfy the requirements.

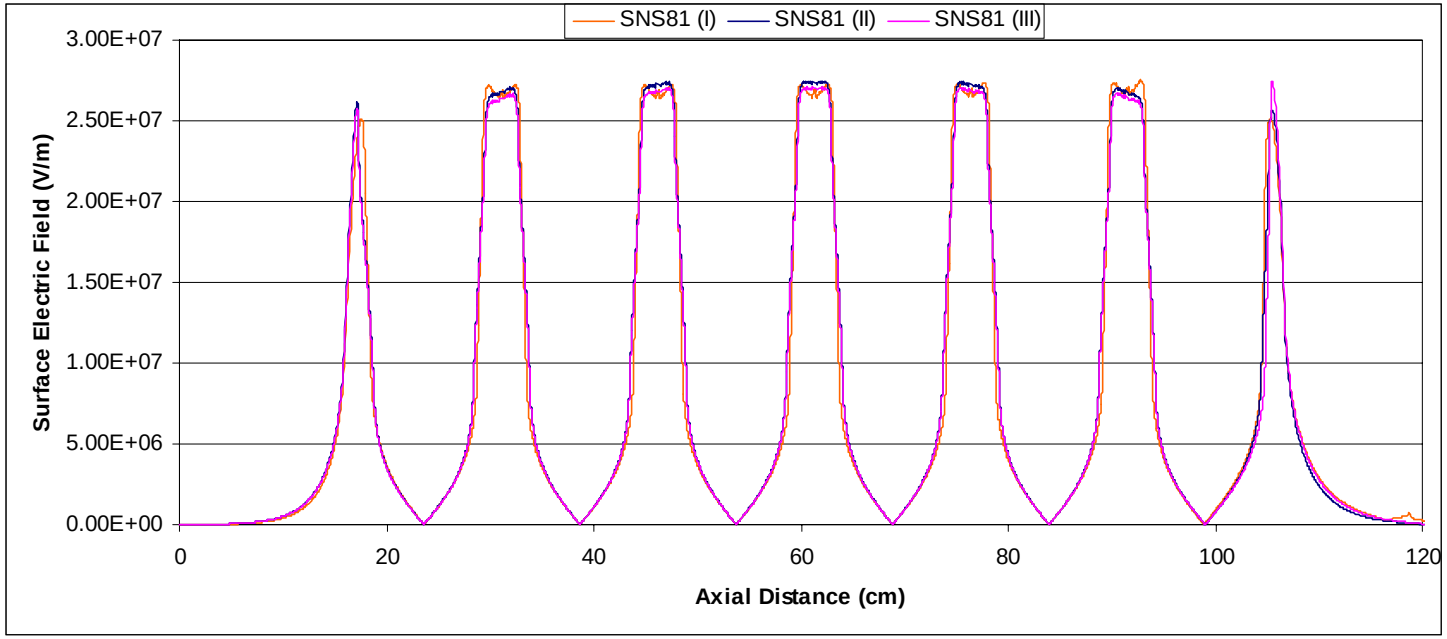
-With about 6.7 cm and below beam pipe radius;

right end cell can be tuned with same equator diameter of mid cell→3 Dies

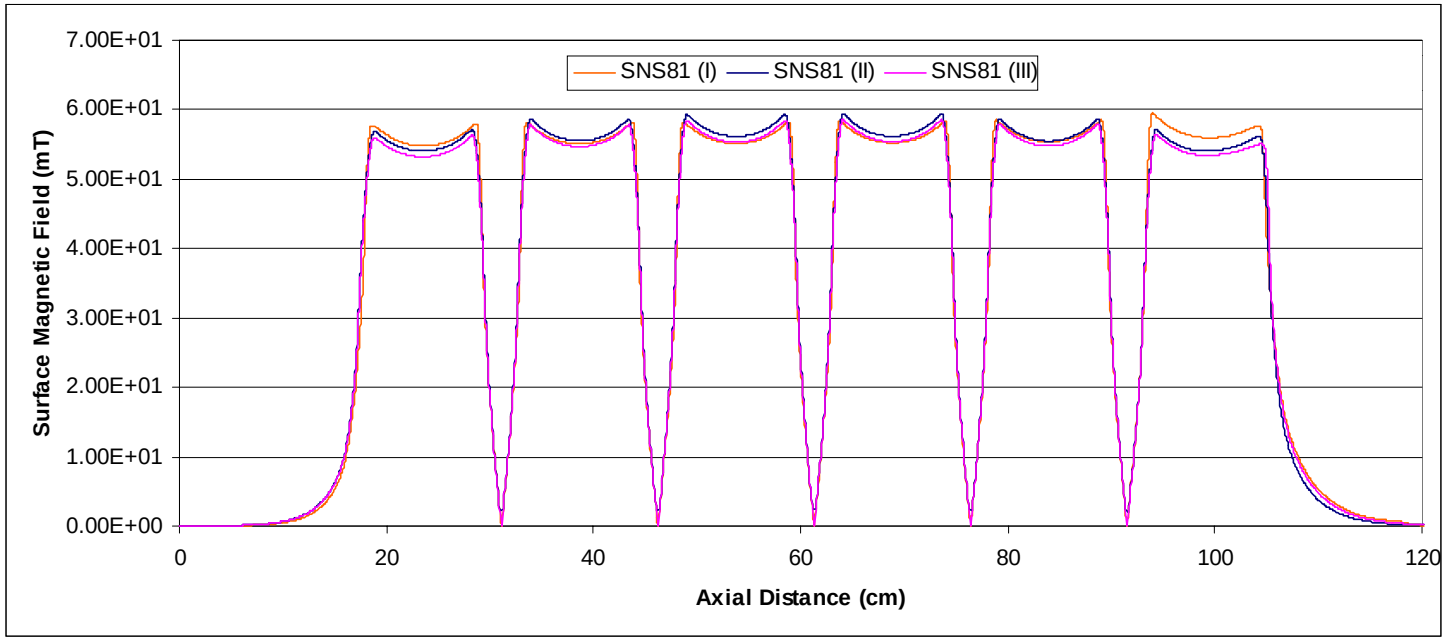
Qex issues will be presented here, and HOM analysis is under progress.



Surface Electric Field Along the Surface

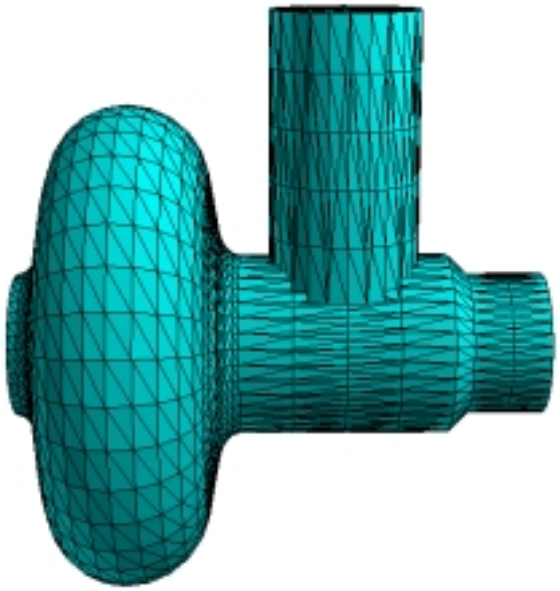


Surface Magnetic Field Along the Surface

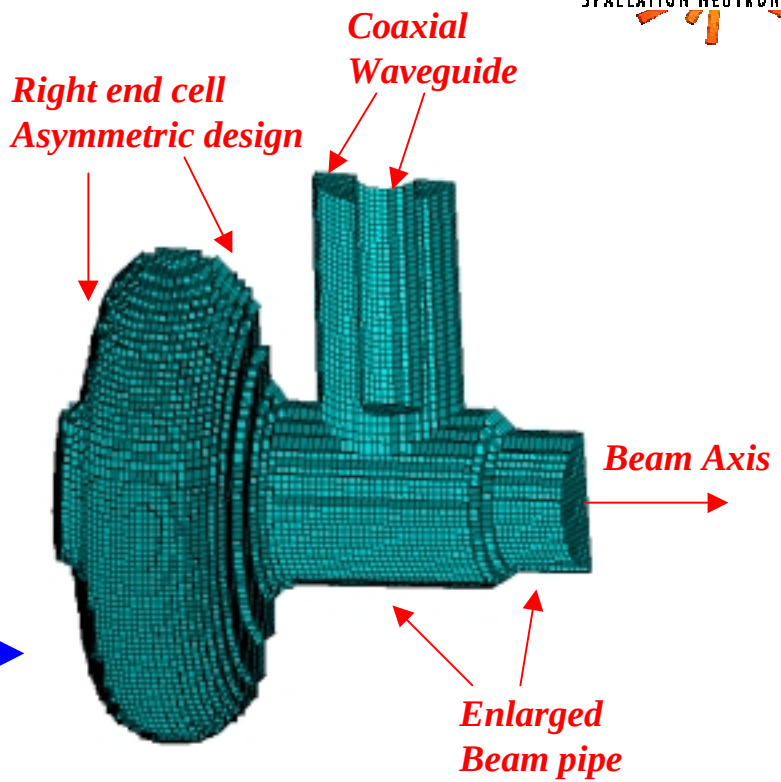


Qex Calculation (I)

Right end cell generation under MAFIA :



3-D Geometry generated



Solid Model of MAFIA
(500,000 meshing points)

-Adding the wave guide break the cylindrical symmetry of the cell, we can not use a 2D code.

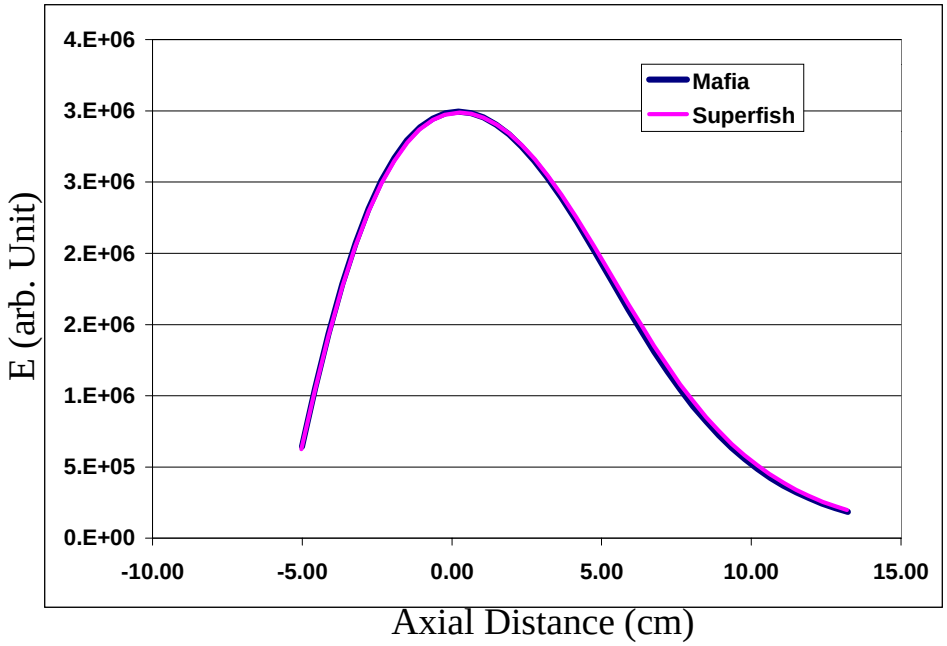
-Model the right end cell of the cavity with MAFIA.

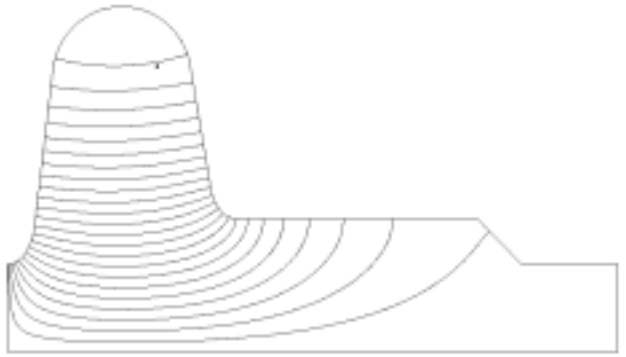
Qex Calculation (II)

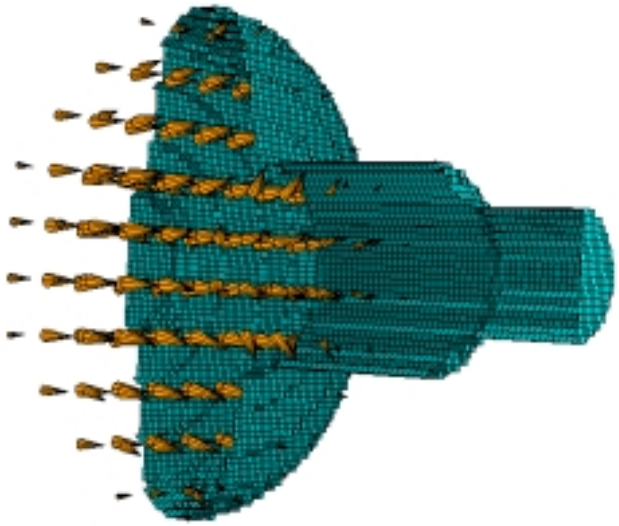
Comparaison MAFIA / Superfish :

Meshing :	**400,000 points**	**0.1 cm_mesh size**
Frequency :	**806 MHz**	**805 MHz**

Axial Field of Right end cell (without coaxial wave guide)







-MAFIA results for the right end cell seem in good agreement with Superfish results.
-Superfish gives us the ratio Ucav/Urightcell needed to calculate Qex.

Qex Calculation – Parameters of the study

$$Q_{ex} = \omega U / P_{ex}$$

ω : resonance frequency
U : stored energy
Pex : power flowing out through the coupler

What can affect Qex ?

1) GOC (Geometry of Coupler)

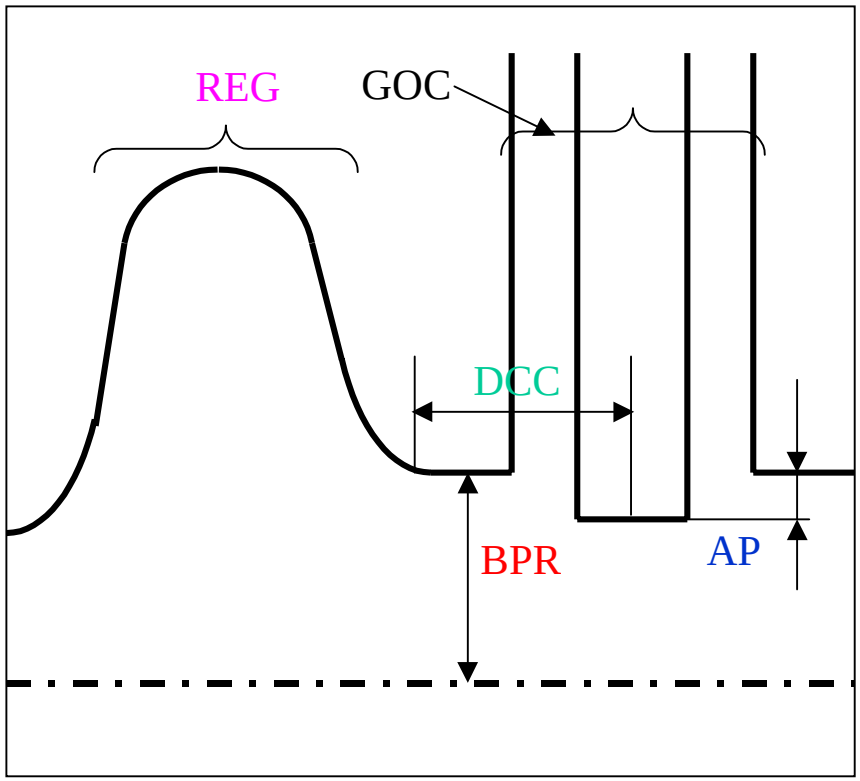
2) BPR (Beam Pipe Radius)

3) REG (Right End-cell Geometry)

4) DCC (Distance between Cavity and Coupler)

5) AP (Antenna Penetration)

Right end cell drawing :



Hereafter Qex dependencies are presented in concerning about the above factors except 1) GOC. The GOC used here is from JLAB.

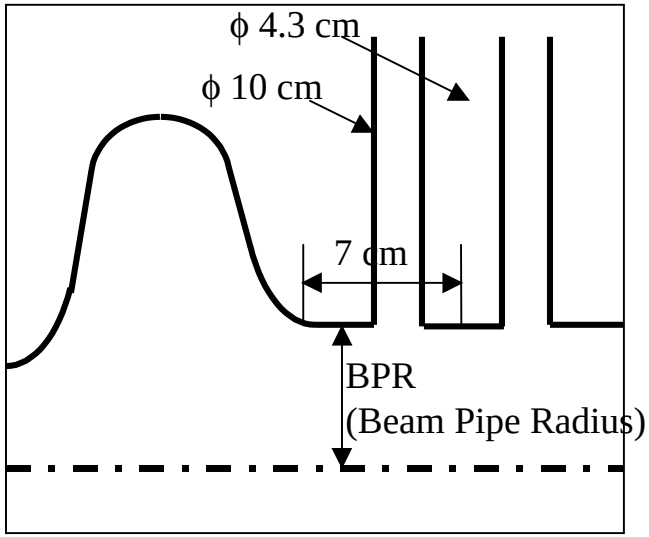
Qex Calculation (III)

$$Q_{ex} = \omega U / P_{ex}$$

ω : resonance frequency
U : stored energy
Pex : power flowing out through the coupler

- Scheme for Qex calculation
  ref. Pascal Balleyguier, "External Q Studies for APT SC-Cavity Couplers," Proc. of LINAC98, pp133 (1999)
  Travelling wave in the coaxial line results from two MAFIA runs with different boundary conditions

Right end cell graphic :



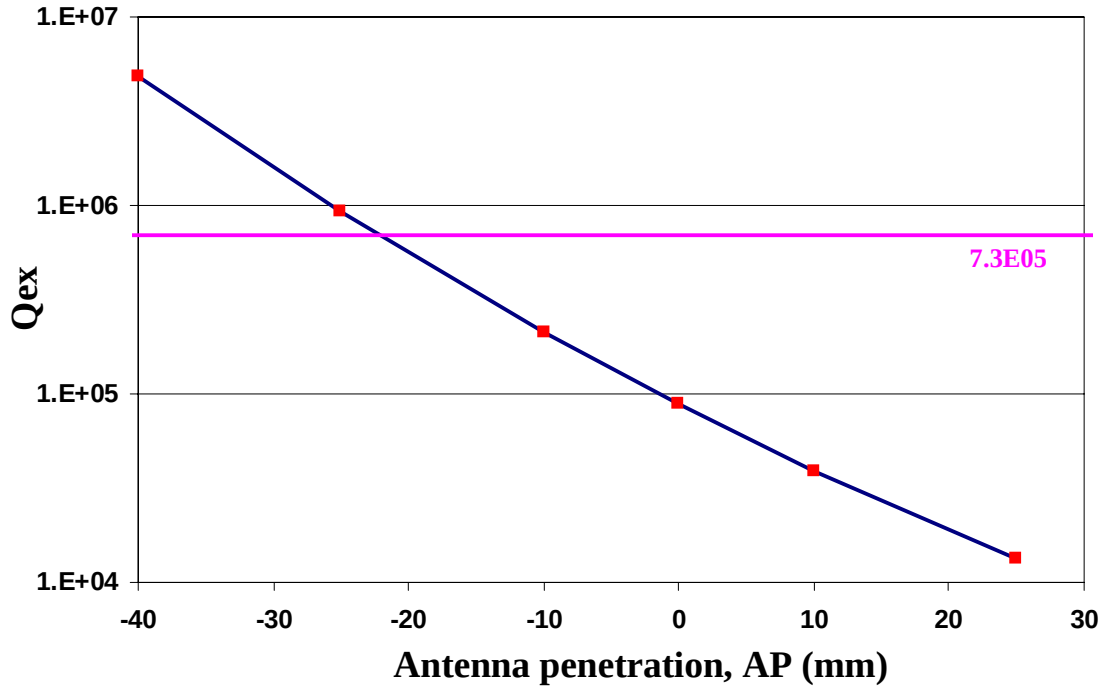
	SNS 61	SNS 81 (I)	SNS 81 (II)
Epeak (MV/m)	27.5	27.5	27.5
Bpeak (mT)	58	58.8	58.8
Field Flatness (%)	~2 %	~2 %	~2 %
Ep/E0	1.88	1.53	1.55
R/Q (Ohm)	302 at β=0.64	505 at β=0.83	515 at β=0.85
Bore Radius (cm)	4.3	4.88	4.85
Beam pipe radius at FPC (cm)	6.5	7	6.2
Inter-cell Coupling (%)	1.61	1.61	1.59
Number of dies, required	4	4	3
Qex	9.0E+04	1.2E+05	1.9E+05

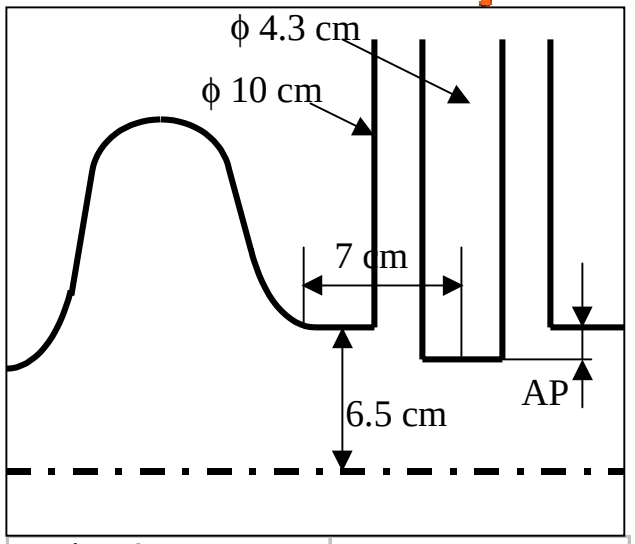
% Qex ; inner conductor tip at reference position (no penetration)
% FPC; Fundamental Power Coupler

Qex Calculation - Antenna Penetration dependency (I)

Variation of Qex for different antenna positions (AP) :

-SNS β=0.61 cavity
-Qex needed; ~7.3E05
-Ucav/Uright = 5.41



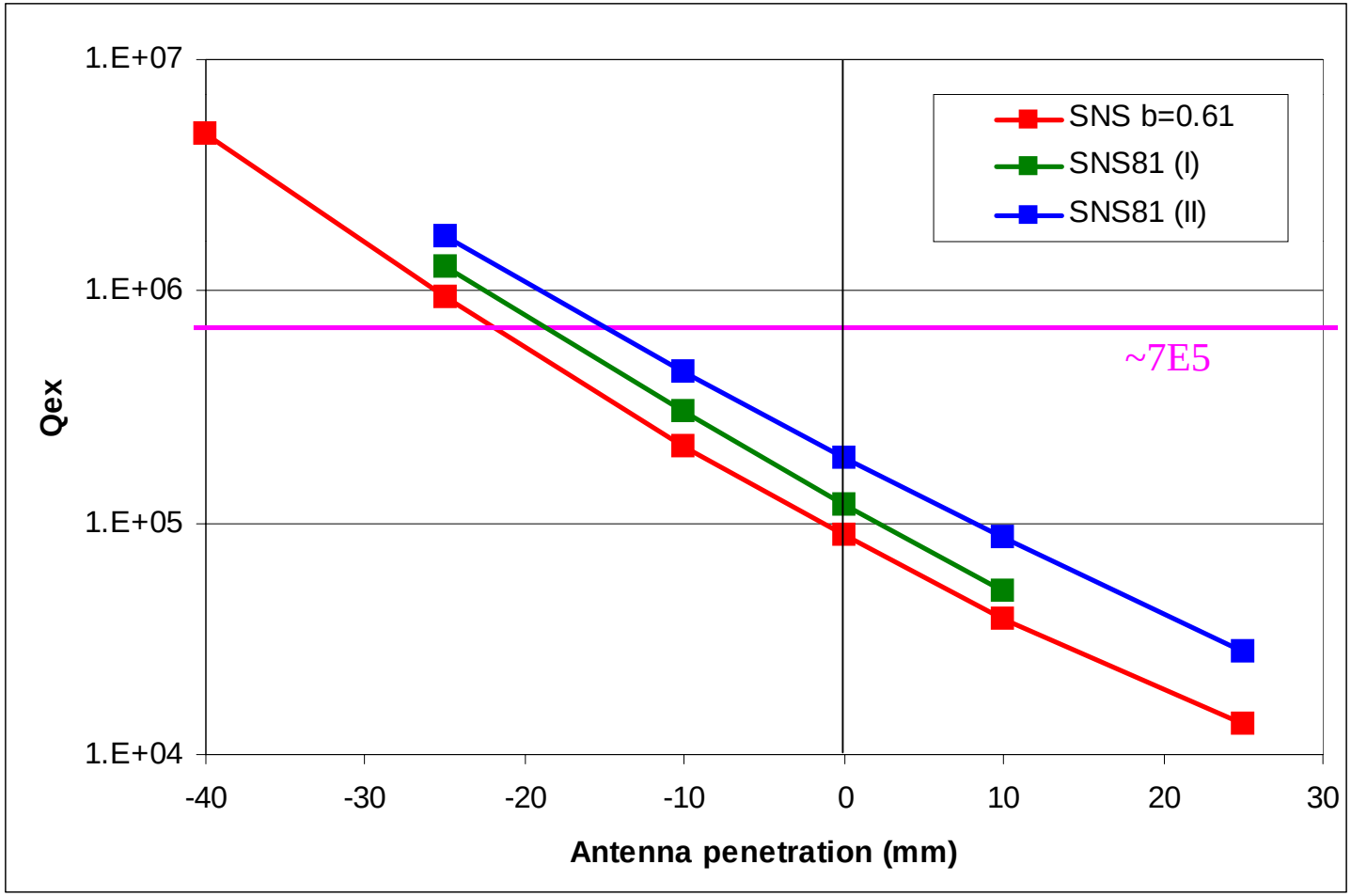


Mesh 4e05

Antenna penetration (mm)	Qex
-40	4.81E+06
-25	9.38E+05
-10	2.14E+05
0	8.91E+04
10	3.87E+04
25	1.35E+04

- A variation of 25mm corresponds to one order variation of Qex.
- The value of 7.3E05 can be achieved by pulling the antenna in the wave guide (~23 mm)

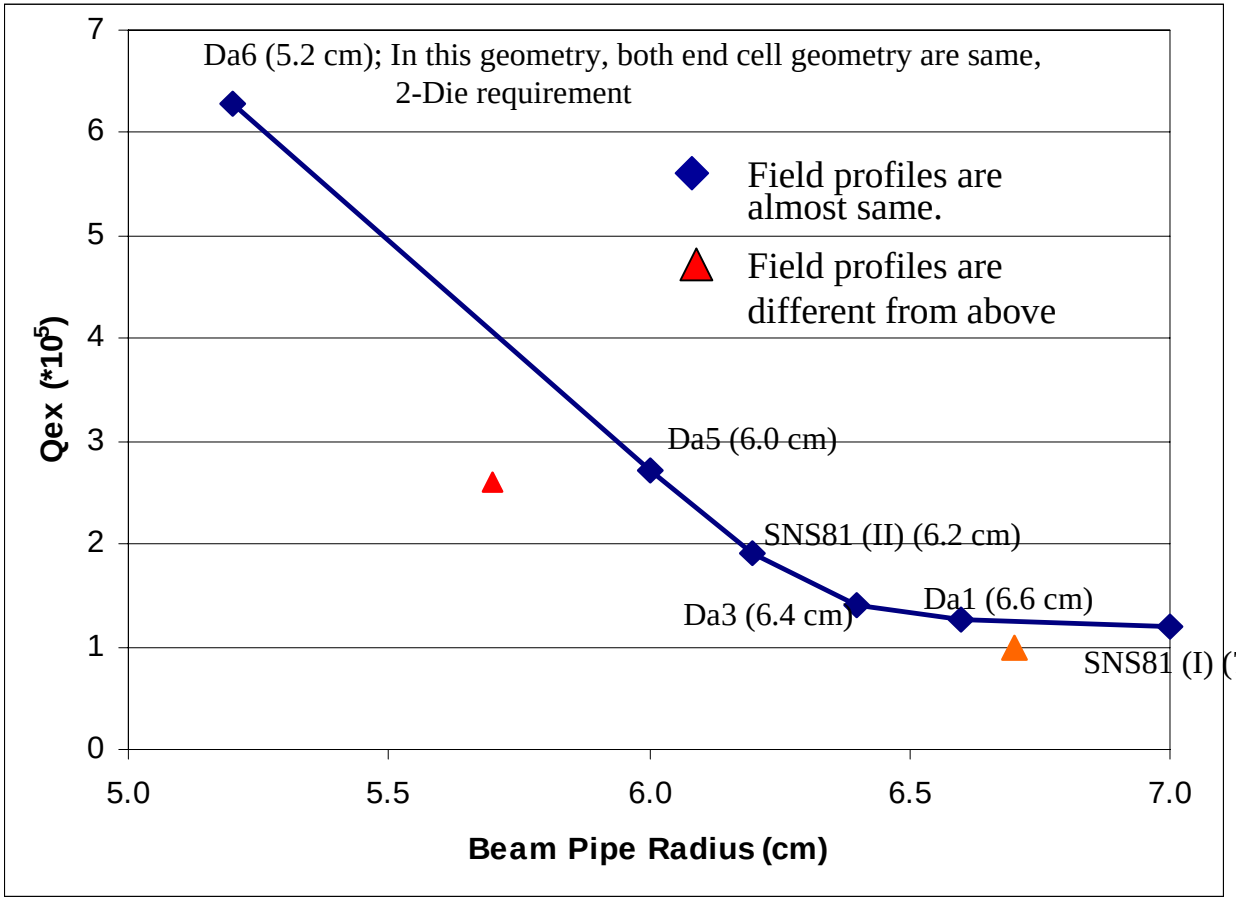
Qex Calculation - Antenna Penetration dependency (II)



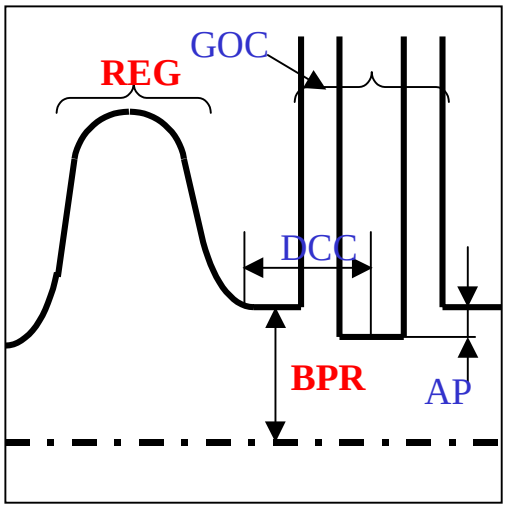
1) GOC (Geometry of Coupler); Fixed
2) BPR (Beam Pipe Radius); Fixed for each line
3) REG (Right End-cell Geometry); Fixed for each line
4) DCC (Distance between Cavity and Coupler); Fixed at 7 cm
5) AP (Antenna Penetration); x-axis

Qex Calculation - Beam Pipe Size Dependency (I)

(β=0.81 cavity)



Right end cell drawing :



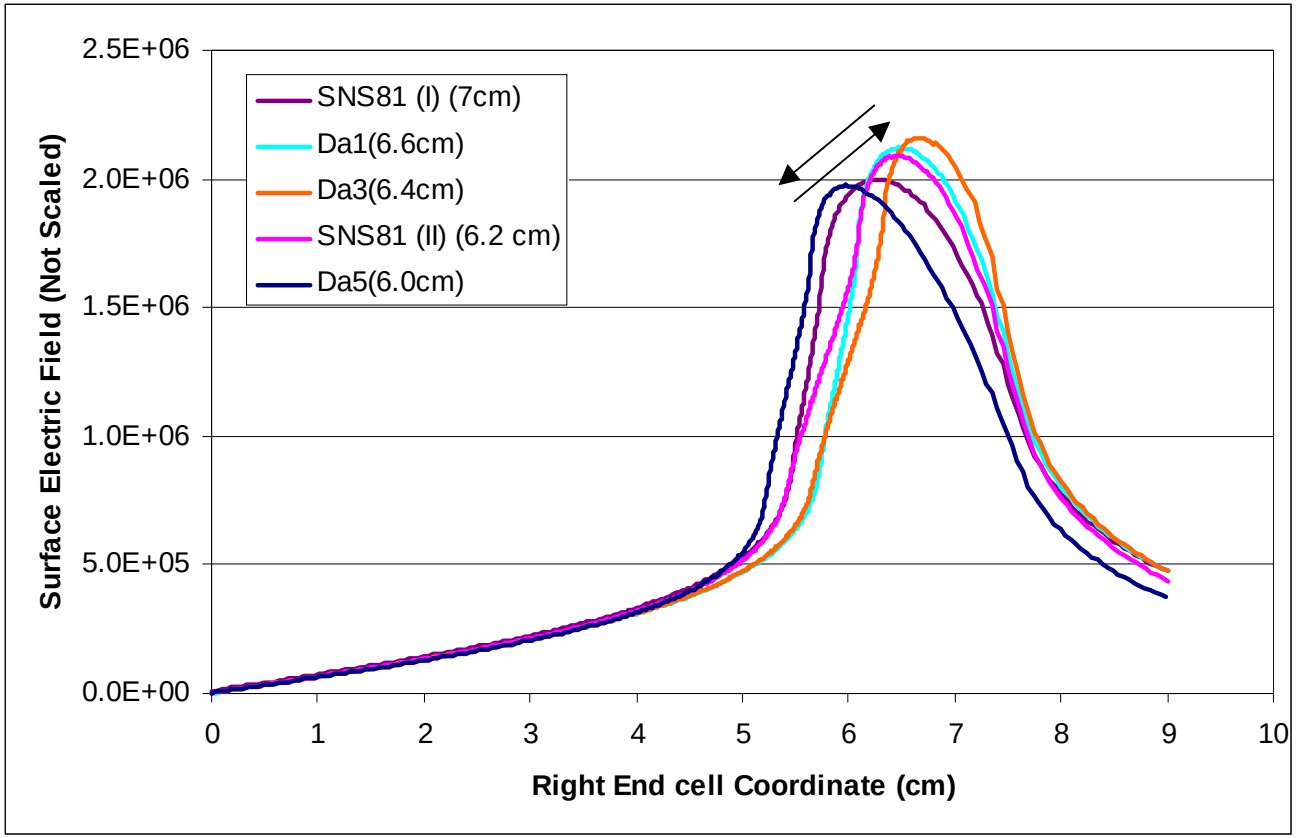
different BPR
different REG
AP=0 cm
DCC=7 cm
GOC = Fixed

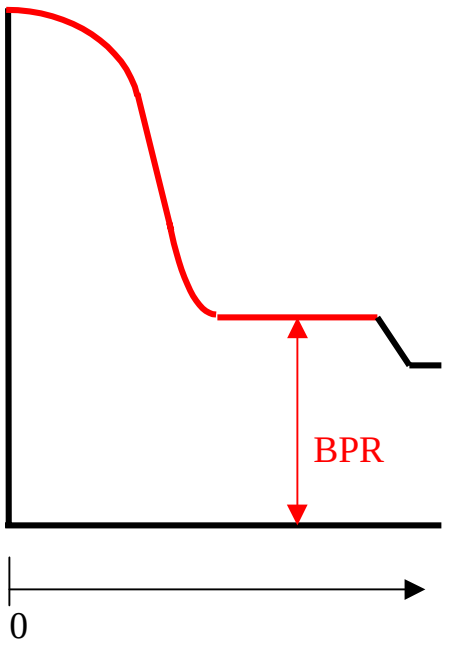
1) GOC (Geometry of Coupler); Fixed
2) **BPR (Beam Pipe Radius);** *x-axis*
3) **REG (Right End-cell Geometry);** *different for each BPR*
4) DCC (Distance between Cavity and Coupler); Fixed
5) AP (Antenna Penetration); fixed

BPR and REF are changed together since these are coupled.

Qex Calculation - Beam Pipe Radius Dependency (II)

Surface Electric Field Profile Comparison (β=0.81 cavity)

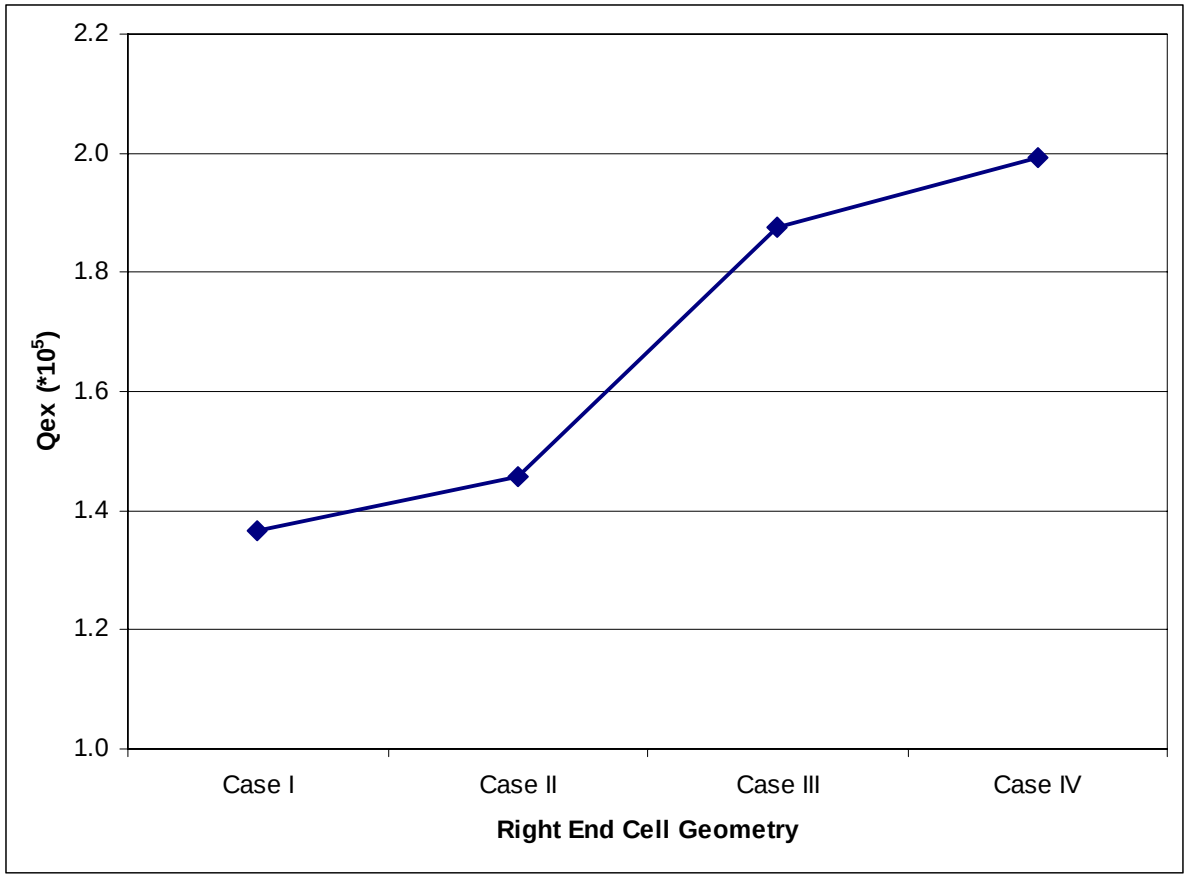


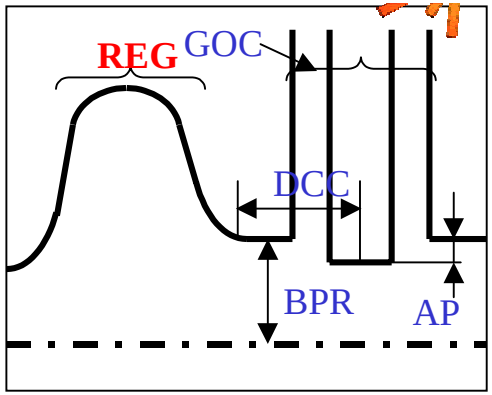


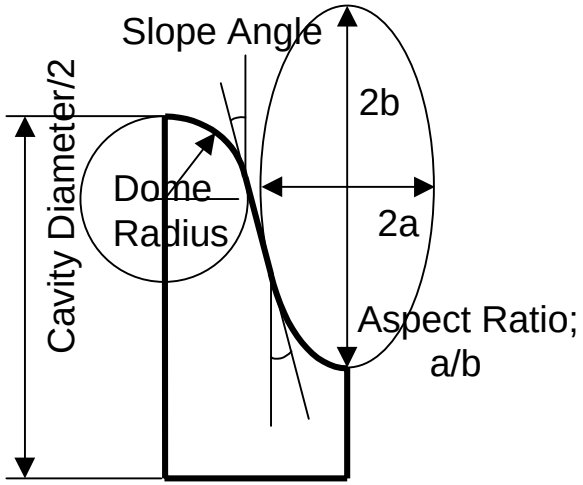
From a certain beam pipe diameter, the contribution of beam pipe size to Qex is small.

Qex Calculation - Right End Cell Geometry Dependency (I)

(β=0.81 cavity) Different REG at AP=0 cm, DCC=7 cm, BPR= 6.2 cm.





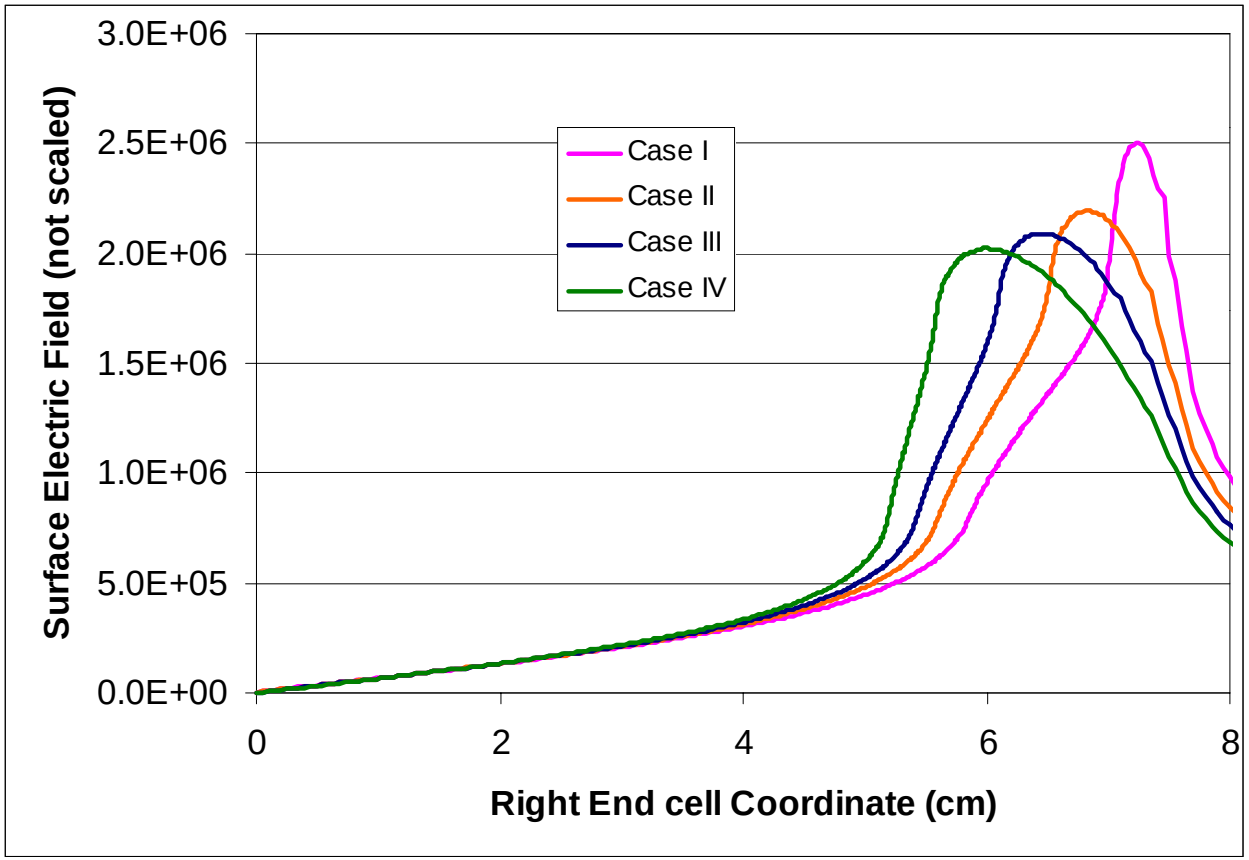


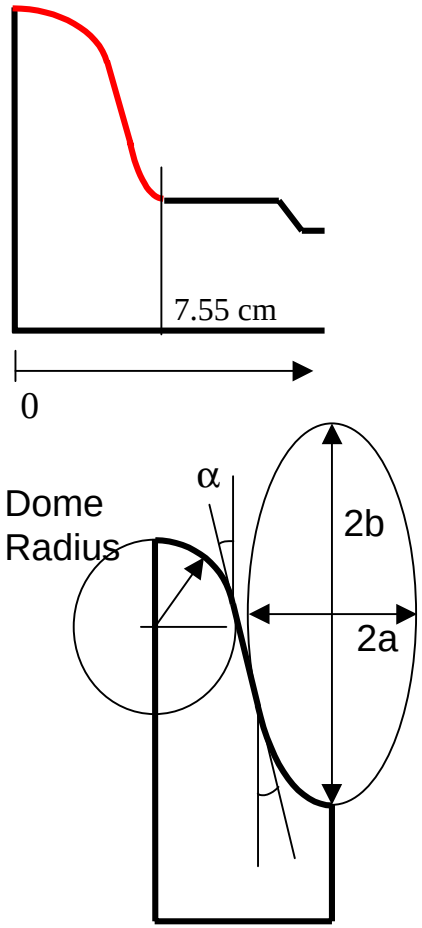
1) GOC (Geometry of Coupler); Fixed
2) BPR (Beam Pipe Radius); Fixed at 6.2 cm
3) REG (Right End-cell Geometry); x-axis
4) DCC (Distance between Cavity and Coupler); Fixed at 7 cm
5) AP (Antenna Penetration); fixed at 0 cm

	a (cm)	α (degree)	Dome Radius (cm)
Case I	0.55	13.00	6.00
Case II	1.00	11.50	5.71
Case III	1.50	9.70	5.50
Case IV	2.00	7.00	5.24

Qex Calculation - Right End Cell Geometry Dependency (II)

Surface Electric Field Profile Comparison (β=0.81 cavity)





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Case I	0.55	13.00	6.00
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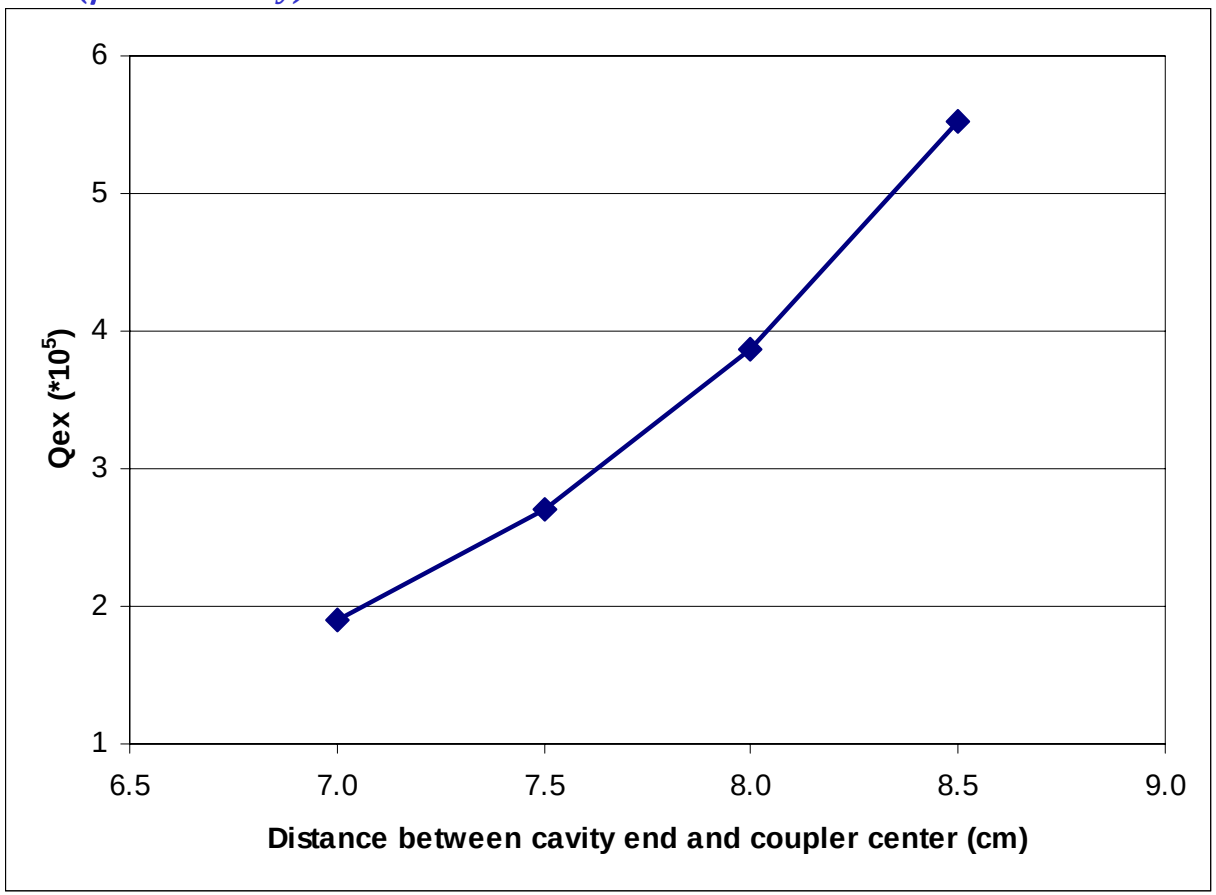
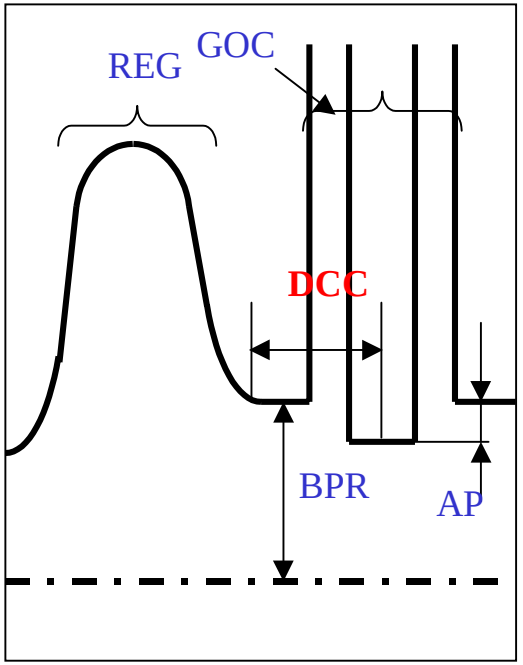
Adjusting the right part of right end cell can control Qex.

Qex Calculation - DCC Dependency

(β=0.81 cavity)



Right end cell drawing :



Different DCC

AP=0 cm
BPR= 6.2 cm,
REG fixed
GOC fixed

1) GOC (Geometry of Coupler); Fixed
2) BPR (Beam Pipe Radius); Fixed at 6.2 cm
3) REG (Right End-cell Geometry); Fixed
4) DCC (Distance between Cavity and Coupler); x-axis
5) AP (Antenna Penetration); fixed at 0 cm

SUMMARY

-Qex behaviors are examined with fixed coupler geometry and by changing;

1) **AP** (*Antenna Penetration*)
   ; Dependencies are quite large
2) **BPR** (*Beam Pipe Radius*)
   ; Up to a certain radius, the dependencies are large,
   from a certain radius, its contribution is small
3) **REG** (*Right End-cell Geometry*)
   ; Ellipse dimensions at iris affect Qex
4) **DCC** (*Distance between Cavity and Coupler*)
   ; Dependencies are modest (restricted by permitted space)

- With around 60 mm or higher beam pipe radius, the SNS Qex is satisfied with sufficient engineering margin.